Pinpoint: Electrophysiology Planning Tool

Remember the time you reached into your bag and rummaged around for an item, like a water bottle? Sometimes, you could not see what you were doing and had to just feel around and guess. When neuroscientists plan and execute an electrophysiology experiment, they often encounter a similar situation.

Electrophysiology is the process of using electrode probes placed inside the brain at specific locations to record electrical activity. The brain works by having cells relay signals to each other. Whenever a cell relays a signal, it gives off an electrical pulse. One way to understand the brain is to place electrodes inside, record these pulses, and discern the reasons for them. However, a major problem with placing anything inside the brain is that the brain is opaque! Targeting structures deep in the brain with high accuracy requires intense training and expertise. Using their knowledge of the brain's anatomy, neuroscientists must try their best to guess what structures of the brain they *could* be encountering based on where they inserted their probe and the electrical signals they are reading out. This process is further complicated by variability across animals, blood vessels, or other inserted probes getting in the way of the desired path. Every moment a scientist wastes trying to rework an insertion or guess where they are in the brain is time they could have been spending on their research. This is where Pinpoint comes in to help.

Pinpoint is a software platform designed to help neuroscientists accelerate their electrophysiology experiments. Scientists can access Pinpoint through a web browser, right on their laptop. In Pinpoint, scientists view a transparent 3D model of the brain and highlight different regions of interest. They can then insert virtual probes into the brain and maneuver them to hit desired recording sites. While scientists are moving probes around, Pinpoint is

calculating in real time where probes will need to be inserted *in vivo* and to what depth. Pinpoint can also notify scientists if a certain insertion is impossible due to constraints or collisions. Because the insertions are simulated virtually, scientists can easily reroute probes and try a different pathway, something that is very difficult to achieve in the middle of a live recording. These are things that Pinpoint can help scientists do when planning an electrophysiology experiment. But Pinpoint is also capable of assisting scientists *during* the experiment.

Over the summer of 2022, I developed a system that enabled Pinpoint to interface directly with electrophysiology manipulators like the Sensapex uMp Micromanipulators. Utilizing standardized web technologies such as WebSockets I designed a server application that can be easily installed on the computer that manages the manipulators and connects them directly to Pinpoint. This system enabled scientists to view in real-time the positions of probes inside the brain while driving them with manipulators *in vivo*. By automatically moving the virtual probes to match their positions in real life, scientists can view what regions of the brain they are encountering while driving their probes. This allows them to understand where they are in the brain and whether they have reached their target destination (see fig. 1 to view Pinpoint in action). In addition, if scientists need to drive further or deviate from their original recording depth, they can do so more easily knowing where their probes are in the brain. No more rummaging around in a bag, scientists can now see exactly what they are looking for and target it precisely!

The next step for Pinpoint is to automate the probe insertion process. This is achievable by utilizing the system I made to connect Pinpoint to electrophysiology manipulators and send signals to drive the manipulators to pre-planned positions. The goal is for scientists to pre-plan their electrophysiology experiment inside Pinpoint on their laptop and simply hit a button and

allow Pinpoint to do the rest. On average, setting up an electrophysiology rig and positioning probes manually can take 30 minutes to an hour, and our goal is to cut that time in half or even more with Pinpoint.

Pinpoint is being developed as open-source technology with collaboration in mind. My project mentor, Dr. Daniel Birman and I worked on software features both independently and together in pair programming sessions. As open-source software, the project is also designed to allow anyone else to contribute and expand upon Pinpoint for their needs. Many software tools in academia are one-off tools a single scientist developed for their project. Over time, these tools become obsolete, and no developers stayed to help maintain and support them for other labs. Pinpoint was designed to be an open and flexible platform capable of connecting with any lab's equipment and any electrophysiology workflow. Dr. Birman and I often accompany other scientists doing recordings in the Steinmetz Lab to get feedback on how useful the current iteration of Pinpoint is and if there are any features we should consider adding. We have also just started to share Pinpoint with outside laboratories through the recent UW Neuropixels course, but there is more work to be done sharing and demonstrating our project to new users.

From this research project, I hope to gain experience and practice in developing something that makes an innovative impact. I came to UW as a computer science student who wanted to get involved in research. In the world of computer science, developing something new is often driven by its revenue potential rather than its value to the community. My interest in computer science and technology stems from my drive to improve things. When I see problems or inefficiencies, I seek ways to solve them. I wanted to get myself involved in research because research is how real groundbreaking innovations happen. Working on Pinpoint has not only allowed me to contribute an innovative solution to the neuroscience community, but I have also

gained experience iterating a product with researchers, learning about what scientists need, and understanding the general workflow of the research world.

My plan for awards received by this scholarship is to fund outreach and collaboration efforts with other labs to expand the platform. Having the funds to travel to scientific conferences and other laboratories to demonstrate Pinpoint would leave a great impact on the neuroscience community. The project has been met with enthusiasm from researchers here in the Steinmetz Lab and we would like to bring that experience to other neuroscience labs as well. Talking to other labs will also allow us to learn more about what specific hardware platforms other labs depend upon and get feedback on how we can make Pinpoint even better for their research. Research is a collaborative effort and working with other scientists from labs within UW and beyond is how we can make Pinpoint a platform that can improve electrophysiology for the wider neuroscience community.

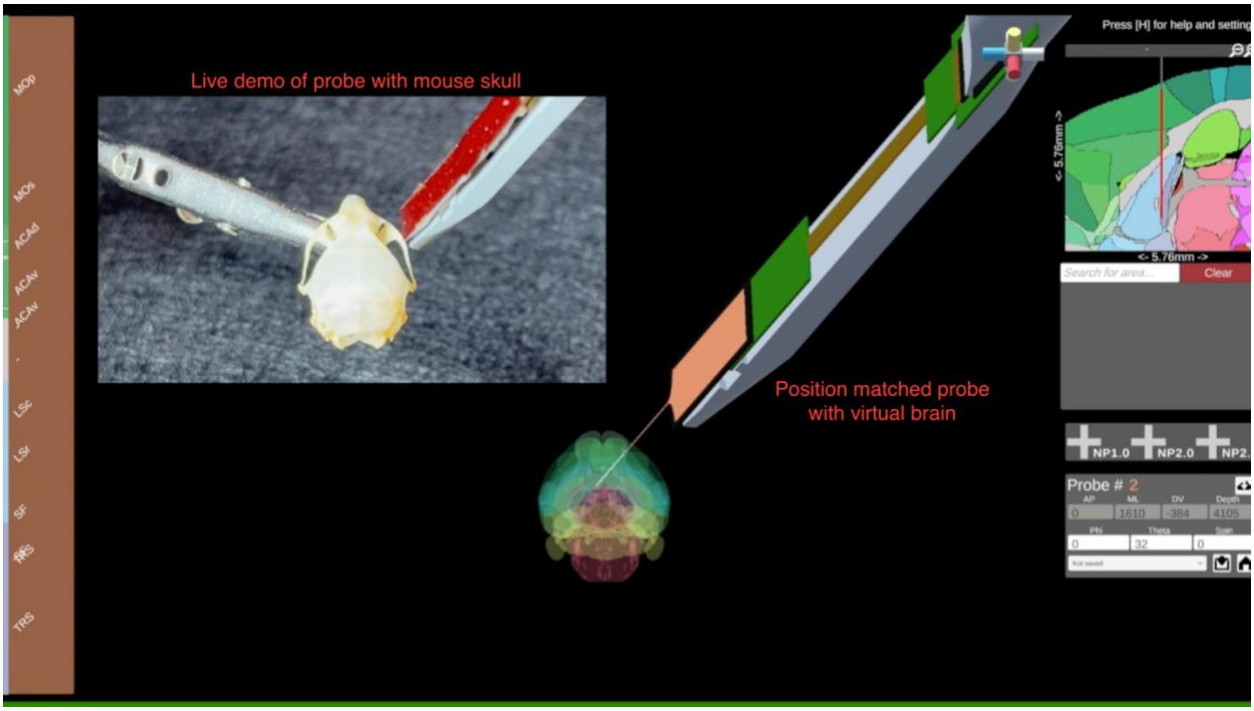

Figure 1 - Screenshot from Pinpoint demo video. See full demo here: https://www.youtube.com/watch?v=_dGe-PESiE0.